AUTOMATED FUMIGATION AND NEUTRALIZATION SYSTEMS FOR FORMALDEHYDE GAS

B. W. MITCHELL[1], G. C. WITCHER, and J. HAMMOND
Southeast Poultry Research Laboratory, U.S. Department of Agriculture, Agricultural Research Service, 934 College Station Rd., Athens, GA 30605
Phone: (706) 546-3443
FAX: (706) 546-3161
E-mail: bmiychell@seprl.usda.gov

Primary Audience: Researchers, Quality Assurance Personnel, Engineers, Poultry Scientists, Veterinarians

SUMMARY

Formaldehyde gas fumigation has been recognized for many years as an effective decontamination procedure to sterilize a variety of airborne and surface microorganisms. Although automated systems are commercially available to generate formaldehyde gas, they tend to be very expensive and more complicated than is necessary for many applications. Also, they do not provide any means of assuring that gas levels are safe for occupancy by personnel following a treatment. Over a period of several years, areas in approximately 15 buildings at the Southeast Poultry Research Laboratory in Athens, GA have been decontaminated with a very basic, manually mixed, formaldehyde gas generation system. The decontamination was followed by several hours of mechanical clearing of the gas, using remotely operated exhaust fans. Interest in maximizing worker safety and providing simple and affordable fumigation led to the design of the automated systems described in this paper – one for formaldehyde gas generation, the other for formaldehyde gas neutralization. Proper use of these systems minimizes formaldehyde exposure risk for workers. Both systems can be easily constructed, and they have been used successfully for several years.

Key words: Bio-safety, decontamination, fumigation, sterilization
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DESCRIPTION OF PROBLEM

Decontamination of poultry or animal housing areas over the last few decades has often involved the use of formaldehyde gas which, although very effective [1, 2, 3, 4], is a known carcinogen [4]. Various approaches have been used to release the gas, which is usually generated by adding formalin to potassium permanganate. The process by which the gas is generated has varied over the years from manual systems to automated cookers. In a typical manual system, a worker places a can with the appropriate amount of potassium permanganate in it in the room to be treated. Formalin is then added to the can, and the worker quickly leaves the building since rapid formaldehyde gas production takes place immediately. This approach would create a potentially serious safety hazard if the fumiga-

[1] To whom correspondence should be addressed

tion worker were to trip on the way out of the building.

Safer approaches for generating formaldehyde gas for large spaces have included steam ejectors or the use of electric cookers – typically made from paraformaldehyde and modified electric fry pans containing a low vaporizing fluid such as silicone [1]. The cookers are preset for the desired temperature and the worker leaves the room. By setting the thermostat to 400°F and pressing a momentary contact switch, the heat relay is latched (activated and held) and the cooker slowly raises the temperature of the fluid. This process causes formaldehyde gas to be generated. When all of the paraformaldehyde is evaporated, the fluid will rapidly rise to 400°F and the thermostat will de-energize the latching relay and turn the cooker off. One disadvantage of the cooker system is that large rooms may require multiple gas generators, but a typical electrical circuit can handle only one cooker without overloading. Another disadvantage is that the cookers have to be modified to include a momentary switch and a latching heat relay [1], or remote circuit breakers in safe areas have to be readily available to turn the cookers on and off.

This report describes another type of system developed at this laboratory. This system greatly simplifies the generation of formaldehyde gas and permits numerous generators in a room without concern for loading of electrical circuits. A formaldehyde neutralization system is also described. Discussion topics will include design and construction details, cleaning requirements for spaces to be treated, formulations, examples of applications, and results.

Materials and Methods

FUMIGATION AND NEUTRALIZATION SYSTEM CONSTRUCTION DETAILS

The automated fumigation system (Figures 1A and 1B) consists of a PVC (polyvinyl chloride) tank whose outlet is controlled by a timer-operated solenoid valve. This system, which is attached to a support bracket, is placed in a fumigation can – typically a heavy duty 33 gal (125 L) galvanized trash can. The neutralization system (Figures 2A and 2B) consisted of a 6-qt deep-fat fryer modified by the addition of an extension at the top and a timer. The cooker used 1400 watts of power – typical for electric skillets; thus, only one cooker per electrical circuit could be used.

GENERAL PROCEDURES FOR FUMIGATION

The space to be treated needs to be airtight and thoroughly washed down and rinsed prior to fumigation since the fumigation is effective only on airborne or surface microorganisms. All ventilation should be turned off. It is highly desirable that the ventilation system have remotely accessible controls or switches which allow the system to be turned back on when the fumigation process is completed. The worker should wear gloves, goggles, and a respirator with a filter capable of protection from formaldehyde fumes while measuring the formalin and potassium permanganate.

The recommended material mix is 0.6 g potassium permanganate and 1.2 cc formalin (37% formaldehyde) per ft^3 (0.0283 m^3) of air space. It is preferable for the relative humidity in the space to be approximately 70% since the sterilant is not effective below 60% and since humidities above 90% depress formaldehyde concentration. Gas contact time should be from 4 to 12 hr, following which the exhaust fans should be operated for 12 to 24 hr to clear the air. Alternatively, the neutralization system described below and shown in Figures 2A and 2B can be used to neutralize the formaldehyde gas. Personnel using either the fumigation or neutralization systems should have at least basic training in laboratory safety, including the use of toxic chemicals and gases.

DETAILED PROCEDURES FOR FORMALDEHYDE GENERATOR SYSTEM

- Check the solenoid for leaks and proper operation by using water instead of fumigation materials prior to each use with formalin solution.
- Place the system on the fumigation can, add the appropriate amount of formalin in the PVC dump tank, and check again for leaks.
- Set the timer for 30 min and add the potassium permanganate to the fumigation can.
- Plug the timer into a 120 Vac electrical outlet and promptly leave the area. The timer will automatically dump the

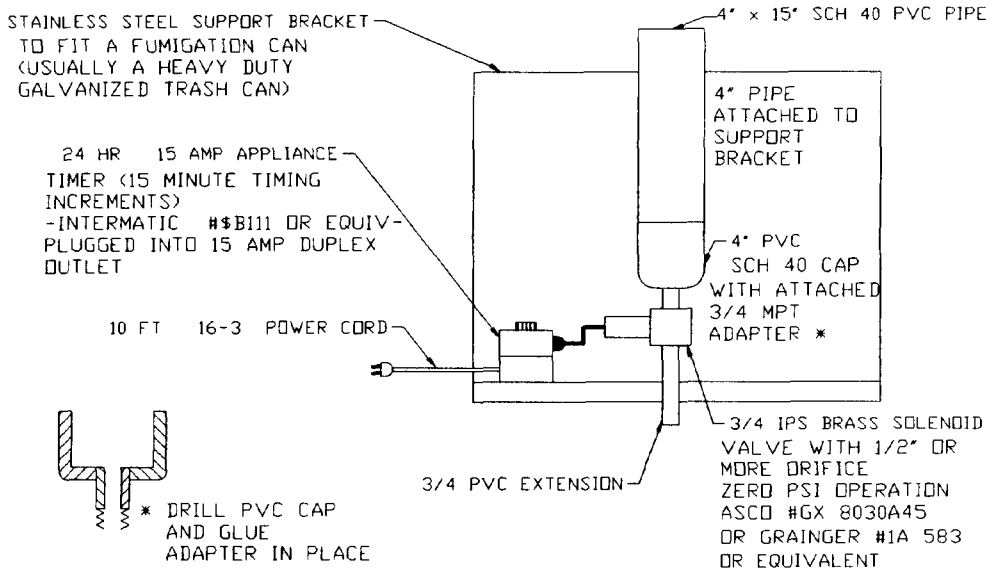

FIGURE 1A. Drawing of the timed remote formaldehyde fumigation system

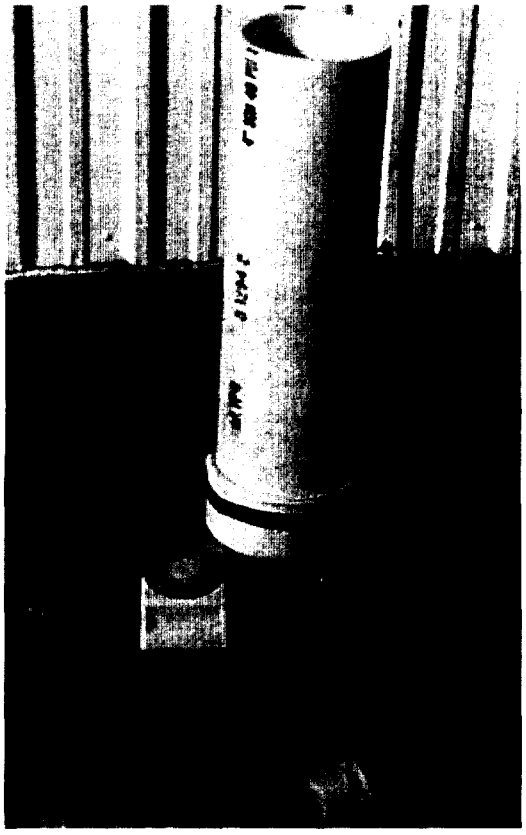

FIGURE 1B. Photograph of the timed remote formaldehyde fumigation system

formalin into the potassium permanganate at the end of the 30-min period. Water should be flushed through the solenoid valve after each use to minimize the buildup of formalin crystals, which can cause valve failure.

NEUTRALIZATION SYSTEM PROCEDURES

Formaldehyde gas can be neutralized with ammonium carbonate by placing 0.04 oz/ft^3 (38.8 g/m^3) into the skillet of the automatic formaldehyde gas neutralization system (Figures 2A and 2B) prior to fumigation, setting the cooker thermostat between 375 and 400°F, setting the timer (for 30 min heating time with a delay of 4 to 12 hr to give the formaldehyde gas sufficient contact time), and plugging the timer into a 120 Vac receptacle. After the delay time, the cooker will turn on and heat up for 30 min, vaporizing the ammonium carbonate. The neutralization process should be given 1 or 2 hr to work, following which the building exhaust will remove the ammonium carbonate gas. Our experience has shown that neutralization can take place with approximately half as many neutralization units as there are fumigation units.

The length of time needed for a complete treatment, neutralization, and ventilation cycle varies according to the available ventilation in the treatment area. The entire process

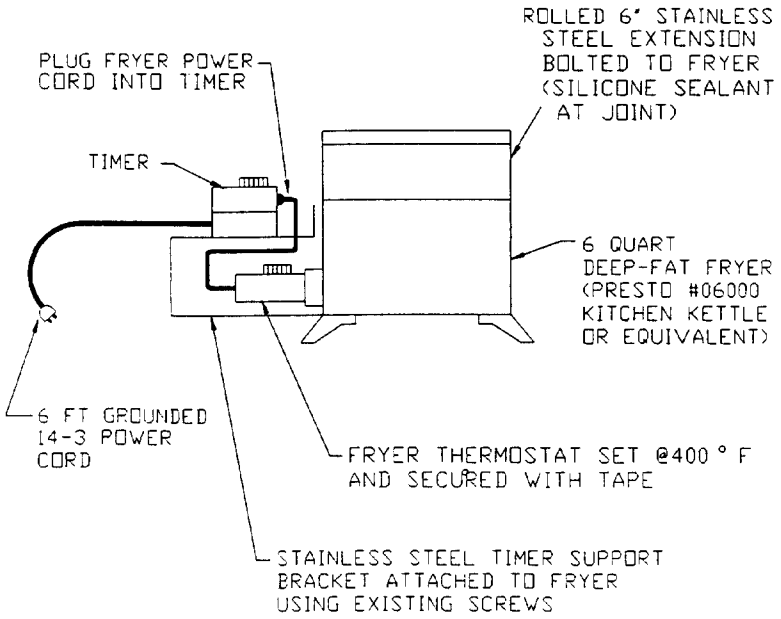

FIGURE 2A. Drawing of the timed remote formaldehyde gas neutralization system

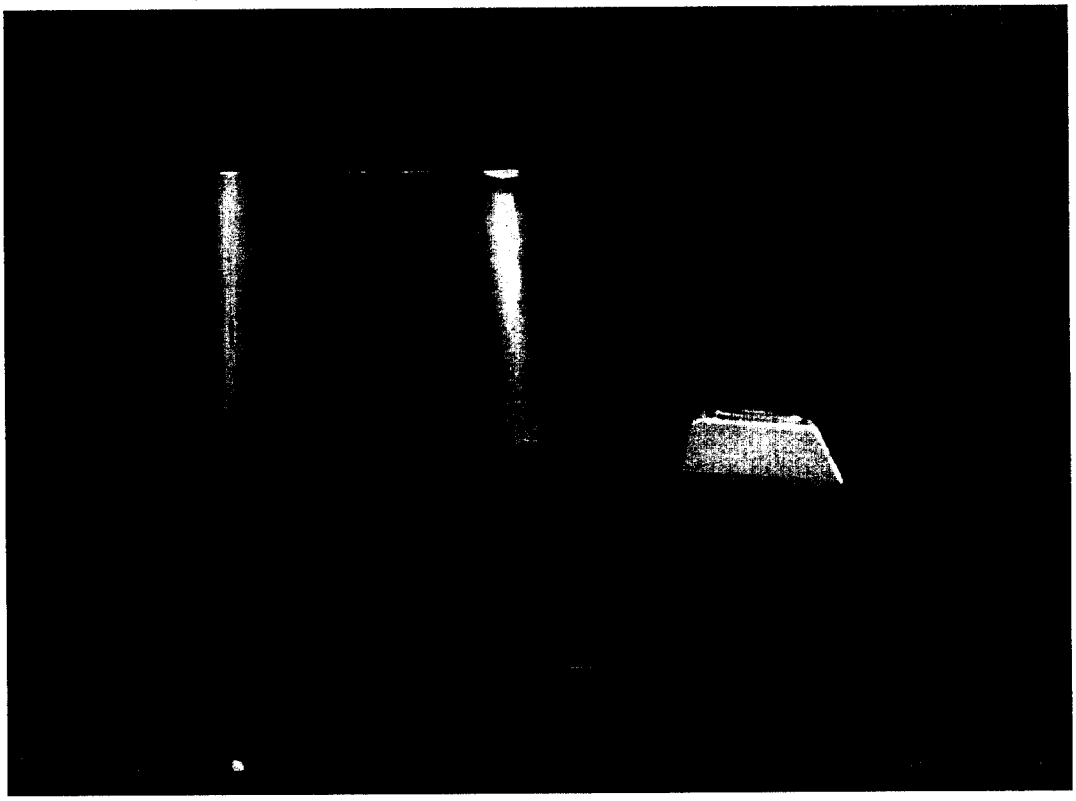

FIGURE 2B. Photograph of the timed remote formaldehyde gas neutralization system

of fumigation and neutralization can potentially be accomplished overnight if the fumigators are set to go off at the end of a work day and the neutralizer system is set to come on during the night (*e.g.,* could allow fumigation from 4:00 p.m. to 4:00 a.m. and neutralization from 4:00 a.m. to 7:00 a.m., followed by manually turning on the exhaust system for a couple of hours to get the space ready for occupancy by 9:00 a.m.). Workers should enter the treated space for the first time very carefully to verify that the treatment and exhaust operation cleared the gas sufficiently. In our tests of the system, full face respirator masks with formaldehyde cartridges have been used along with personal formaldehyde sensor badges [5] with a TWA (time weighted average) sensitivity of 0.75 ppm for 8 hr or 0.02 to 10 ppm for 15 min.

Results and Discussion

The simple, low-cost fumigation and neutralization systems described above have been used effectively at this laboratory for various poultry disease research isolation rooms and for FAPP (Filtered-Air Positive-Pressure) production houses for several years with minimal electrical and mechanical problems. Room air sampled following fumigation and ventilation or neutralization consistently showed the formaldehyde levels to be undetectable (less than 0.02 ppm). The approximate cost of the fumigation system is $250: based on $150 for parts and $100 for labor. The neutralization system costs approximately $80: $55 for parts and $25 for labor.

An indication of disinfection effectiveness has been the consistent ability for several years, following decontamination with the system, to maintain disease-free status in areas repopulated with disease-free poultry from our FAPP houses as confirmed by annual serological tests. These areas include various sizes of isolator cabinets and rooms which have housed birds infected with influenza, Newcastle Disease Virus, or *Salmonella enteritidis* as well as the FAPP production houses. Negative serology from birds in experimental control cabinets during the year has also confirmed the effectiveness of the system. Most failures were mechanical or electromechanical and involved the timers, the thermostat on the cooker, or the solenoid valve on the dumper. These parts were easily replaced. The systems should also be useful for numerous other decontamination applications such as egg rooms, incubators, commercial-sized hatching cabinets, hatchery areas, small research buildings, and others.

Conclusions and Applications

1. Simple, low-cost fumigation and neutralization systems can be easily constructed and used effectively for various poultry disease research isolation rooms and for FAPP (Filtered-Air Positive-Pressure) production houses.
2. The systems can be expected to last for several years with minimal electrical and mechanical problems.
3. Applications other than those described include any enclosed space up to a few thousand square feet where it is desired to use formaldehyde gas as a disinfectant. Examples include hatchery areas, egg rooms, feed rooms, entry areas to production houses, biological labs, and small poultry production houses.

References and Notes

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